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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

ENVIRONMENTAL CONTROL & LIFE SUPPORT SYSTEM GROUP

RISK MANAGEMENT PLAN

Prepared by:
Flight Projects Directorate
Flight Systems Department
ECLSS Group
Systems Team

MSFC – Form 454 (Rev. October 1992)

Environmental Control & Life Support System Group
Risk Management Plan

This plan documents the approach of Risk Management as tailored for the Environmental Control and Life Support System (ECLSS) projects within the ECLSS Group. It is applied to ECLSS projects as a means to anticipate, mitigate and control risks and to focus project resources where they are needed to ensure success of the project. This plan is prepared in response to the requirements/guidelines of NPG 7120.5A, NASA Program and Project Management Processes and Requirements.

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1.0 SCOPE/PURPOSE

This plan has been developed for the Oxygen Generation System (OGS), Water Recovery System (WRS), and the Vapor Compression Distillation Flight Experiment (VCD-FE) of the Environmental Control and Life Support Systems (ECLSS) Program for the International Space Station (ISS).

The Risk Management Plan establishes methods of identification, mitigation, tracking, and project control of risks for mission success under established budget and schedule constraints.

The ECLSS Group (Code FD21), within the MSFC Flight Projects Directorate (Code FD01), has overall technical and project management responsibility for each project and the responsibility of assuring all project objectives are met. Project Managers in the ECLSS Group have been assigned responsibility for the implementation of all required in-house and contracted activities and to provide overall project direction. Each Project Manager is responsible for technical, cost, and schedule performance.

The ECLSS Systems Group will provide a Systems Engineer as a Risk Management Lead Engineer to assist each project office in establishing and implementing a Risk Management process in accordance with NPG 7120.5A.

Risk Management is a continuous evaluation process which includes each project team to evaluate and proactively address, track, and mitigate all associated risks. This plan will be updated as required to reflect changes and improvements to the Risk Management process.

1.1 ASSUMPTIONS, CONSTRAINTS, AND POLICIES

This plan is the implementation of Risk Management requirements for the applicable Project Plan, listed in section 2.0 APPLICABLE DOCUMENTS. The Project description, organizational diagram, schedule, and resources allocation are listed in the Project plan.

This plan addresses the requirements, methods, and tools used in the ECLSS Risk Management process. This plan shall be controlled at the project level through the processes described in the MSFC Station Life Support Projects Office Data Management Plan (SLS-JA21-001). The Risk Assessment Database (RAD) shall be maintained by the Risk Management Lead Engineer.

2.0 APPLICABLE DOCUMENTS

The applicable Project Management Plan directs the activities of the individual projects. The Risk Management Plan is subordinate to and an integral part of each of the Project Management Plans.

Document Number	Title
ISSP-JPD-306	ISS Joint Program Directive, "Establishment of the Program Risk Management System"
SLS-OGS-008	ISS Oxygen Generation System Project Plan
SLS-WRS-008	SLS Water Recovery System Project Plan
SLS-VCD-001	VCD-FE Project Plan
SSP 50134	ISSA Risk Summary Card
NPG 7120.5A	NASA Program and Project Management Processes and Requirements
N/A	Continuous Risk Management Guidebook

3.0 ACRONYMS/ABBREVIATIONS

The following acronyms are related to this Risk Management Plan.

CRM	Continuous Risk Management
ECLSS	Environmental Control and Life Support Systems
GMR	Group Monthly Review
ISS	International Space Station
ISSA	International Space Station Alpha
JSC	Johnson Space Center
MSFC	Marshall Space Flight Center
OGS	Oxygen Generation System
RAD	Risk Assessment Database
RM	Risk Management
RMLE	Risk Management Lead Engineer
SLS	Station Life Support
TPR	Top Program Risk
VCD-FE	Vapor Compression Distillation Flight Experiment
WRS	Water Recovery System

4.0 CONTINUOUS RISK MANAGEMENT OVERVIEW

This section provides an overview of the Continuous Risk Management **(**CRM) process and its relation to Project Management, including primary activities, process steps, terms, and definitions.

Details of the CRM process along with actions, tasks, and tools specific to each Project, are provided in subsequent sections of this plan.

There are six primary activities of the CRM process:

- Risk Identification: continuous efforts to identify, acknowledge, and document risks as they are found.
- Risk Analysis: an evaluation of all identified risks to estimate the probability of occurrence, severity of impact, time-frame of expected occurrence or when mitigation actions are needed, classification into sets of related risks, and priority ranking.
- Risk Planning: establishes actions, plans, and approaches for addressing risks and assigns responsibilities and schedules for completion. Metrics for determining the risk status are also defined during this step.
- Risk Tracking: an activity to identify, compile, and report risk attributes and metrics which determine whether or not risks are being mitigated effectively and risk mitigation plans are being performed correctly.
- Risk Controlling: an activity that utilizes the status and tracking information to make a decision about a risk or risk mitigation effort. A risk report may be accepted, closed, or watched, a mitigation action may be re-planned, or a contingency plan may be invoked. Decisions on the appropriate resources needed are also determined during this activity.
- Risk Communicating and Documenting: an overt action to communicate and document the risk at all steps of the CRM process. This can be in the form of an action item log, risk information sheet, risk database, mitigation plan, status report, tracking log, and/or meeting decision.

4.1 RISK MANAGEMENT PROCESS AND DATA FLOW

Figure 1. Illustrates the CRM process flow for the individual projects. The diagram depicts the functional relationships of the identification, planning, analyzing, tracking, and controlling activities and overlays the reporting and communication activities. This section provides a description of the detailed process steps.

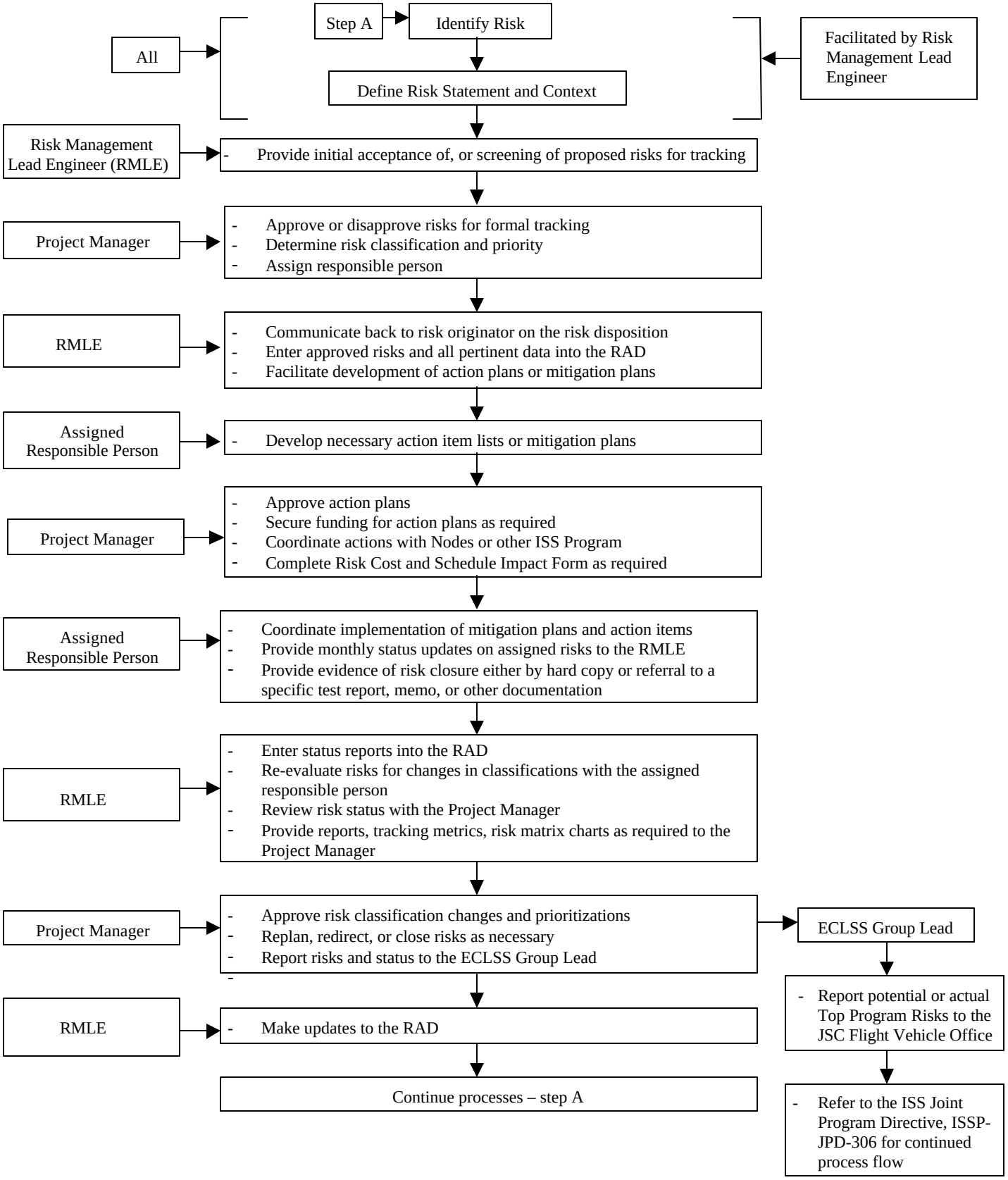

Figure 1. Project Risk Management Process and Data Flow

4.1.1 IDENTIFYING RISKS

A baseline set of risks shall be identified and entered as risk statements in the Risk Assessment Database (RAD). Risk statements shall be written clearly and concisely, citing only one risk condition, and one or more consequences of that condition. All other relevant information shall be captured as Context or Historical Events describing the circumstances, contributing factors, and related issues. Good context provides the what, how, when, where, and why of the risk condition. The RMLE shall assign each risk a unique risk identification number. The Project Manager will assign a responsible person as the risk owner. The person's name shall be entered in the RAD. The RMLE is the owner of the RAD process.

All project personnel are responsible for identifying new risks. New risks identified during project related meetings shall be captured and added to the RAD upon Project Management approval of the risk. It is the responsibility of the RMLE to make sure this is accomplished.

4.1.2 ANALYZING RISKS

Each risk shall be evaluated using the applicable evaluation method, as recommended in SSP 50134, ISSA Risk Summary Card and the Continuous Risk Management Guidebook, Chapter 5, to determine impact, probability of occurrence, and timeframe. Each risk shall be examined to determine its relationship to other risks already being tracked. Initially, the Project Manager will provide an estimate of these attributes. The assigned responsible individual shall provide recommendations for changes in classification to the RMLE The criteria for analyzing risks are established in Section 6.0 Risk Classification.

The Project Manager is responsible, with support from the RMLE, for re-prioritizing risks from the applicable project to determine the risks ranking for that Project. The applicable ECLSS Project Manager exercises discretion on which risks shall receive mitigation resources.

4.1.3 PLANNING AND CONTROLLING RISKS

As newly identified risks are brought to Project Manager's attention through periodic team meetings and database reports, the applicable Project Manager shall determine whether to keep the risk and may delegate responsibility for the risk.

All risks shall be assigned to a specific team member for responsibility. Responsibility for a risk means that the person must answer for the status and mitigation of the risk. To help disposition the risk, this person may also assign risk mitigation actions to other team members, or may recommend actions to the Project Manager for his/her assignment of action responsibilities.

Risk planning requires decisions to perform or not to perform further research, acceptance of the risk by documenting rationale in the database, risk closure decisions, watching and documenting the risk attributes and status, and/or creating a mitigation plans to mitigate the risk.

Watched risks shall be documented by status reports, which shall be documented in the RAD. Mitigation activities shall be documented in the RAD by an action item list or through mitigation plans. Mitigation plans may consist of strategies, goals, schedule dates or tracking requirements as determined necessary by the Project Manager. If the risk mitigation requires re-allocation of, or allocation of new project resources, then a Mitigation Plan is required. Mitigation Plans must be approved by the Project Manager.

Decisions shall be made by the Project Manager during the weekly and monthly meetings to close risks, continue to research, mitigate or watch risks, re-plan or re-focus actions or activities, or invoke contingency plans.

4.1.4 TRACKING RISKS

Risk information and metrics defined during planning shall be captured, tracked and analyzed. The person responsible for the risk shall provide routine trend and status reports on research and/or mitigation activities to the Project Manager or designated Risk Management Lead Engineer. All risk information shall be documented in the RAD. Watched risks shall be reported on at the Project Managers discretion. Risk Matrix Charts and metric summary shall be used to report progress to the Project Manager and the ECLSS Office Manager.

4.1.5 RISK CLOSURE

As risks are analyzed and closures are developed, the risks shall be closed by the applicable Project Manager. All risks shall be closed prior to the Functional Configuration and Physical Configuration Audit Review. One or more of the following conditions must occur for risk closure:

- The risk exposure is below an acceptable level as defined in the mitigation plan.

- The risk is considered to have been successfully mitigated and/or the Project Manager accepts that no further action or watching of the risk is required.
- The risk is no longer relevant to the Project due to changed conditions.

The assigned responsible person for the risk shall complete the risk closure section of the Risk Assessment Form, documenting the rationale upon which the decision to close the risk was based. The assigned responsible person and the Project Manager shall sign and date the risk closure section of the Risk Assessment Form. The risk will remain in the RAD as historical, non-active data. Upon closure of some risks, there may be lessons learned that could be beneficial for other organizations. In such cases, the assigned responsible person shall enter the applicable lessons learned on the FD21 Environmental Control and Life Support Systems Website at the following URL: http://www1/FD/JA21/extra/.

5.0 RISK MANAGEMENT ASSIGNMENTS AND COMMUNICATIONS FLOW

This section provides the project personnel functional roles, responsibilities, and communication within the CRM process. CRM is carried out during the day-to-day activities of project personnel as well as during key project meetings.

5.1 PROJECT ORGANIZATION AND COMMUNICATIONS

The applicable Project Management Plan illustrates the structure of the project team along with the organizational role of each team member. The following tables show how the project teams interact with the RM process:

Table I. summarizes the responsibilities of all project personnel performing CRM.
Table II. provides the criteria for communicating and documenting risk information.

Table I. Risk Management Responsibilities

Who	Responsibilities
All Team Members	• identify new risks • define risk statement and context
Assigned Responsible Person	• develop risk mitigation plans and contingency plans • recommend changes in risk classification • coordinate implementation of action items and mitigation plans • collect data and status updates from actions or actionees identified on the risk mitigation plan • provide monthly status updates on the assigned risk to the RMLE • provide evidence of risk closure (either by hard copy or referral to a specific test report, memo, or other documentation)
Risk Management Lead Engineer	• provide initial acceptance of, or screening of proposed risks for tracking • review mitigation plans and risk classifications to ensure consistency and completeness • report risks to the Project Manager • implement or communicate control decisions for risks • maintain RAD • collect and report general risk measures/metrics • prepare risk matrix charts, summary reports, spreadsheets, forms, etc. as required • coordinate communications with applicable Project Manager
Applicable Project Manager	• authorize in-scope expenditures of resources for mitigation • provide risk classification information • provide cost and schedule impact information to the RMLE for entry into the RAD • prioritize or re-prioritize risks • make control decisions (analyze, decide, execute) • assign or change responsibility for risks and mitigation plans within the project • report risks to the ECLSS Group Lead • coordinate communication with ECLSS Group Lead and external customers • review general risk measures/metrics during each quarter to evaluate effectiveness of risk management
ECLSS Group Lead	• report actual or potential top program risks to the JSC Flight Vehicle Office • review and concur with dispositioning of top program risks

Table II. Risk Management Communication

Communication Path	Risk to be Communicated/Documented
From Individuals to Risk Management Lead Engineer	• Any risk that impacts the performance of the flight system, subsystem, or components • Any risk that impacts budget • Any risk that exceeds schedule milestones • Any risk that needs to be transferred to another team • Risks, mitigation plans, and mitigation status
Risk Management Lead Engineer to Project Manager	• Risk listing and summary • Risk status • Mitigation activity status
Project Manager to ECLSS Group Lead and as appropriate the ISS Program Office	• Top risks in the project • Summarize Risk Status at each Monthly Review • Any risk that impacts mission success • Any risk that impacts the technical and scientific aspects of the Project • Any risk that causes slips of schedule milestones • Any risk that negatively impacts NASA's reputation • Risk Status • Any risk that impacts budget
ECLSS Group Lead to Flight Projects Directorate Management and JSC Flight Vehicle Office	• Risks that significantly affect the safety of flight, integrity of the hardware or software, mission success, launch dates, or that require substantial Program resources

5.2 RISK COMMUNICATIONS TO THE ISS PROGRAM RISK OFFICE

Potential or actual Top Program Risks (TPR)s will be reported through the JSC Flight Vehicle Office. The ISS Program Risk Office defines, in the Joint Program Directive ISSP-JPD-306, a TPR as "risks that significantly affect the safety of flight, integrity of the hardware or software, or mission success. TPRs pose a threat to launch dates or require substantial Program resources." The Program Risk process is defined in the Joint Program Directive ISSP-JPD-306.

6.0 RISK CLASSIFICATION

Risks shall be analyzed using the Impact, Likelihood, and Timeframe classifications defined below. Impact classifications are based on Project requirements, mission success criteria, resources, and cost and schedule constraints. Likelihood classifications are intended to provide an order of magnitude estimate based on available quantitative data and qualitative experience.

6.1 IMPACT CLASSIFICATION

Unacceptable (5)

- Schedule Slip - Slip in delivery of the Rack, slip in delivery of major system or subsystem
- Cost Overrun - ≥10% increase to Project budget allocation
- Technical - Loss of mission or critical function

Major (4)

- Schedule Slip - > 1 month ≤3 month delay of deliverables
- Cost Overrun - ≥5% but <10% increase to Project budget allocation
- Technical - Inability to meet power, weight, size, and/or performance requirements

Medium (3)

- Schedule Slip - > 2 week ≤1 month delay of deliverables
- Cost Overrun - <5% increase to Project budget allocation
- Technical - Loss of design margins, some desired technical performance not completely met

Minor (2)

- Schedule Slip - ≤2 week delay of deliverables, potential to recover schedule
- Cost Overrun - minor impact, potential to recover cost
- Technical - small impact to design margins

Minimal (1)

- Schedule Slip - <1 week delay of deliverables, potential to recover schedule
- Cost Overrun - minimal impact, potential to recover cost
- Technical - minimal impact to design margins

6.2 **Likelihood Classification** (prior to mitigation)

Inevitable occurrence (5)

- Cannot prevent occurrence.

Very High Probability of Occurrence (4)

- Occurrence is very likely

High probability of occurrence (3)

- Occurrence is likely

Medium probability of occurrence (2)

- Occurrence is a potential

Low probability of occurrence (1)

- Occurrence is very unlikely

6.3 Time-frame and Exposure Grade Classification

Each RAD Mitigation entry shall have a completion date listed in the action plan or risk mitigation plan. This date or combination of dates shall serve as the time-frame classification.

Once risk items are entered and classified in RAD, the risk will be assigned an exposure grade (Red/Yellow/Green) based on the following combinations of the consequence and likelihood. The exposure grade is also expressed numerically as the product of the likelihood and the impact classifications. This number is used for tracking and reporting purposes.

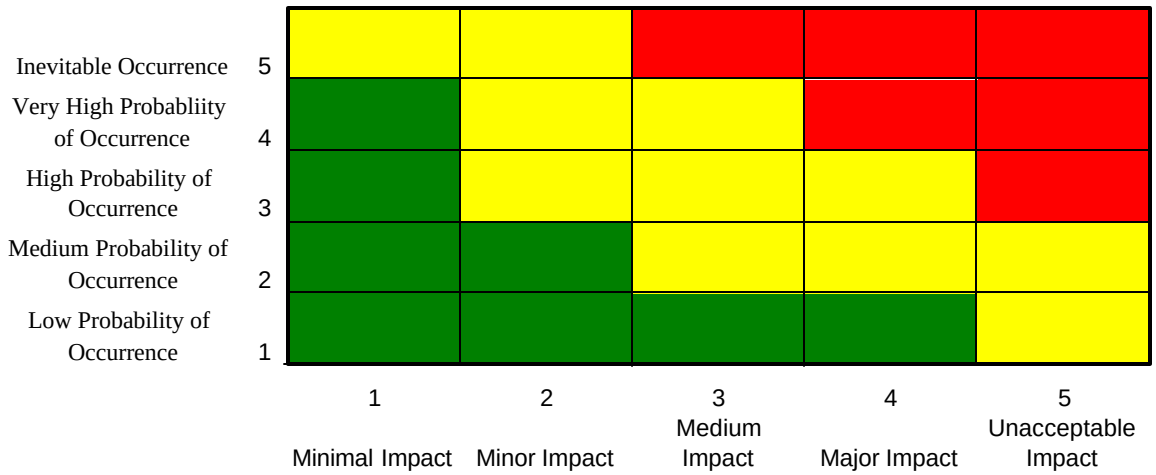

Figure 2. Risk Classification Chart

Items classified as Green are acceptable without further mitigation and shall be routinely tracked for change in status or closed.

Items classified as Yellow may require mitigation. For these items, alternative dispositions may be identified and/or trade studies conducted to determine the mitigation required. Future decision milestones will be identified to enable effective tracking of those risks for which immediate action is deemed not necessary.

Items classified as Red are considered primary risk drivers. For these items, mitigation options will be developed. Red risks will be assessed for impact to budget reserves, and will be tracked to closure.

Time-frame is used in conjunction with the Risk Classification Chart to determine priorities, establish when risks need to have actions taken, and how long risks may need to be watched or tracked before they no longer are a concern or can be closed.

7.0 PROJECT RISK REPORTING

This section describes how the risk information will be documented, retained, controlled and utilized.

Status of the project risk management activities shall be reported as follows:

- The status of each risk shall be summarized and reported to the applicable Project Manager on an as-needed basis.
- Weekly project and team meetings shall include risk status as applicable.
- ECLSS Group Monthly Review (GMR) meetings shall include risk status using Risk Matrices, as required.

All risk information shall be documented in the RAD. The following reports, forms, spreadsheets, and templates shall be developed and used during the execution of the Project Risk Management process:

- RAD
- Risk Assessment Form
- Risk Action Item Spreadsheets
- Risk Matrix Charts
- Tracking Metrics and Trend Analysis Charts

Once a risk has been assigned to a team member, that person will be responsible for updating the risk information. The RMLE shall be responsible for updating the RAD.

8.0 RISK ASSESSMENT/REPORT EXAMPLE

Detailed Report **ECLSS_Risk_DB1** Report Dated Oct 04 1999

Risk 02 ***Hydrogen Sensors*** **Ranked** X **out** X **risk**

System: OGS **Subsystem:** Protonically Pumped Water Loop H2 Sensor

Statement: The use of hydrogen sensors for the detection of hydrogen in water is undeveloped technology both on ground and in microgravity and their response time to hydrogen detection is unknown; Undetected hydrogen leakage or inadequate response to a rapid hydrogen leak into the oxygen side of the system could cause an explosion.

Likelihood: 5 (1=low probability, 5=inevitable

Impact: 4 (1=minimal, 5=unacceptable)

Exposure: 20 (Likelihood) x (Impact) (1 = very low, 25 = very high)

*See Risk Management Plan for Definitions

Date Identified: Jul 14 1999

Responsible: B. Erickson

Risk Area: T, C, S (Technical=T, Cost=C, Schedule=S)

Current Status: Closed

Contingency Plan

TBD

Mitigation Plan

The risk mitigation consists of hardware build and test along with review and analysis of similar systems.

Step	Description	Person	Need Date
10	Development hardware build and test	Hamilton Sundstrand	Feb 01 1999
20	Supply MSFC with a model to install into the OGA for testing	HS / B. Erickson	Jun 01 1999
30	Review shuttle experiment test report when the report becomes	B. Erickson	Jun 01 1999

Historical Events/Status Reports

Date	Person	Description
Jun 01 1998		The H2 detecting system consisted of accumulators and a motorized valve sensing mechanism which proved to be unreliable.
Sep 01 1998		The use of H2 sensors was discussed.
Nov 01 1998		Two manufacturers were contacted regarding the development of H2 sensors.
Dec 01 1998		MAKEL was selected as the manufacturer and plans were made to provide and test the H2 sensors.
Feb 01 1999		Some testing was conducted by MAKEL. MAKEL provided a Phase I test report on H2 sensor feasibility testing in water.
Apr 01 1999		The H2 sensors in the Protonically Pumped Water ORU were eliminated. The system was redesigned and protonically pumped water was replumbed to the water/oxygen outlet. A gas sensor in the protonically pumped water loop will be utilized, and a H2 sensor at the oxygen outlet will provide redundancy.

Risk Closure

Closure Date	Authorization
4/1/99	C. Bramon

Closing Rationale

Risk no longer relevant to project - new design eliminates risk. H2 sensors are no longer required to detect hydrogen in water.